NASA TECHNICAL MEMORANDUM

NASA TM X-74022

NASA TM X- 74022

(NASA-TM-X-74022) SONIC ENVIRONMENT TESTS OF AN INSULATOR/ABLATOR MATERIAL (NASA) 16 p HC A02/MF A01 CSCL 11C

N77-22176

Unclas
G3/24 25112

SONIC ENVIRONMENT TESTS OF AN INSULATOR/ABLATOR MATERIAL

by

L. Robert Jackson, Allan H. Taylor, and Carl E. Rucker

This informal documentation medium is used to provide accelerated or special release of technical information to selected users. The contents may not meet NASA formal editing and publication standards, may be revised, or may be incorporated in another publication.

National Aeronautics and Space Administration

Langley Research Center
Hampton, Virginia 23665

April 1977

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
NASA TM X-74022		

4. Title and Subtitle	5. Report Date
SONIC ENVIRONMENT TESTS OF AN INSULATOR/ABLATOR MATERIAL	April 1977
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
L. Robert Jackson, Allan H. Taylor, and Carl E. Rucker	
	10. Work Unit No.
9. Performing Organization Name and Address	
NASA Langley Research Center Hampton, VA 23665	11. Contract or Grant No.
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address	Technical Memorandum
National Aeronautics & Space Administration Washington, D. C. 20546	14. Sponsoring Agency Code

15. Supplementary Notes

Special technical information release, not planned for formal NASA publication.
Mr. Allan H. Taylor is employed by Vought Corp., Hampton Technical Center, Hampton, Va.

16. Abstract

A 50.8 cm (20 inch) square panel of prepyrolized insulator/ablator was subjected to six 30-minute tests at 160 and 158 dB in the Langley Thermo-Acoustic Fatigue Apparatus (TAFA). This environment simulates the aerodynamic and engine noise encountered by a research airplane while in captive flight on the B-52 pylon during takeoff and climb.

The pyrolized layer sustained damage in the form of three chips and numerous cracks. The chips occurred during the first test. Some cracking resulted during aerodynamic heating tests, and additional cracking resulted from the sonic environment tests.

17. Key Words (Suggested by Author(s))	18. Distribution Statement
Thermal Protection Systems Hypersonics Sonic Fatigue Insulator/Ablator	Unclassified - Unlimited

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price*
Unclassified	Unclassified	16	$3.50

* For sale by the National Technical Information Service, Springfield, Virginia 22161

SONIC ENVIRONMENT TESTS OF AN INSULATOR/ABLATOR MATERIAL

by L. Robert Jackson, Allan H. Taylor, and Carl E. Rucker

SUMMARY

A 50.8 cm (20 inch) square panel of prepyrolized insulator/ablator was subjected to six 30-minute tests at 160 and 158 dB in the Langley Thermo-Acoustic Fatigue Apparatus (TAFA). This environment simulates the aerodynamic and engine noise encountered by a research airplane while in captive flight on the B-52 pylon during takeoff and climb.

The pyrolized layer sustained damage in the form of three chips and numerous cracks. The chips occurred during the first test. Some cracking resulted during aerodynamic heating tests, and additional cracking resulted from the sonic environment tests.

INTRODUCTION

A candidate thermal protection system (TPS) for the National Hypersonic Flight Research Facility (NHFRF) is an elastomeric insulator/ablator material (ref. 1) in two forms, striated and honeycomb reinforced. When heated above 755°K (900°F) the material pyrolizes forming a brittle, charred surface. The pyrolysis process also shrinks the material approximately 10 percent.

Previous research aircraft programs have experienced failures due to the high intensity sonic environment encountered during B-52 captive flight, reference 2. For this reason the material requires exposure to this environment to verify it reuse capability.

The Langley Research Center 8-Foot High Temperature Structures Tunnel (8'HTST) and the Thermo Acoustic Fatigue Apparatus (TAFA) were used to simulate the environment for these tests.

TEST SPECIMEN AND AEROTHERMAL PREPARATION

A stiffened aluminum panel 50.8 cm (20 inch) square was covered with insulator/ablator material. Four 25.4 cm (10 inch) squares, 1.5 cm (0.6 inch) thick, were bonded to the aluminum panel — two squares of striated and two of honeycomb-reinforced material. The panel was subjected to nine 40-second Mach 6 aerothermal tests in the 8'HTST. The 8'HTST tests charred and eroded the surface as shown in figure 1.

SPECIMEN MOUNTING FOR ACOUSTIC TESTING

The test specimen is supported by a 1.91 cm (0.75 inch) thick steel mounting plate that is about 1.70 m (67 inch) square and shown in figure 2. A 50.8 cm (20 inch) square hole in the center of the plate enables exposure of the test specimen to the sonic environment. Two angle members span the hole and attach to the aluminum plate stiffeners. When the mounting plate is installed in the noise facility, the plate serves as the local wall. Figure 3 shows the mounting plate, test specimen, and positions of the four surrounding microphones for monitoring the test parameters as installed in the TAFA.

TAFA FACILITY

Air modulators generate the noise which propagates through the horn and test section, shown in figure 4, and then through a muffler to the outside. Noise facility parameters and available equipment are given in Table 1 along with those used for the tests reported herein. Data acquisition is under computer control. An analog system controls the acoustic loading. Further facility details are given in references 3, 4, and 5.

ACOUSTIC TESTS

Six 30-minute sonic fatigue tests were made at room temperature. Table 2 lists the tests and noise conditions. Random noise was generated over the audio frequency spectrum. A mean frequency of about 800 Hz (Input Band Pass) was used for the first five tests (fig. 5). The mean frequency was increased to about 1600 Hz for the last test (fig. 6), because brittle materials are more sensitive to high frequency, such as the whine of turbojets.

As indicated in Table 2, the initial five minutes of each test was run at a level of 160 dB which is an r.m.s. fluctuating pressure of about ±2000 N/m^2 (±0.29 PSI). The final 25 minutes of each test was run at a level of 158 dB which is an r.m.s. fluctuating pressure of about ±1655 N/m^2 (±0.24 PSI). These dB levels are based on X-15 captive flight data given in reference 2. Figure 5 gives the sound level in dB as a function of frequency for test 5 which is typical for the first five tests. Figure 6 gives the sound level as a function of frequency for test 6. As discussed above, the frequency input band pass is greater for test 6 than for the other five tests.

RESULTS AND DISCUSSION

Pyrolized material chipped off the surface of the specimen at three locations. Figure 7 shows one of the affected areas. The white area with sharp edges is the fracture surface. Also indicated are cracks in the material in the fracture surface and in an adjacent block that was formed by striating the material. Chipping at the other two locations, not shown, was similar to that of figure 7, but originated at the edge of a hole that resulted from loss of an instrument plug during the 8'HTST tests. The three chippings occurred during the first test. No further chipping occurred during subsequent tests.

In the honeycomb-reinforced material, numerous cracks were observed in the pyrolized material after the tests were completed. Figure 8 shows a typical crack pattern observed on most of the honeycomb area. Some cracking is evident after heating and pyrolizing the material; however, additional cracking resulted from the sonic tests. Since the material shrinks by about 10 percent on pyrolizing, residual tensile stresses are generated in the material. The low strength char cracks in areas of highest residual stress during heating or cooling. In the areas of lower residual stress the sonic loads precipitate further cracking. Tests in a Mach 7 stream for specimens with cracks have shown no increase in the aluminum temperature (ref. 6).

CONCLUSIONS

A 50.8 cm (20 inch) square panel of prepyrolized insulator/ablator, both striated and in honeycomb, was subjected to six 30-minute tests to 160 dB. Three chips and numerous cracks occurred. The chips occurred during the first test. Some cracking occurred due to material shrinkage resulting from prior aerothermal tests of the specimen; however, considerable additional cracking occurred from the sonic environment. The material may be reusable with cracks since Mach 7 tunnel tests show no back-face temperature increase; however, water absorption and freezing in the cracks could cause further loss of material integrity.

REFERENCES

1. Brackeen, Richard E. and Marcy, William L.: X-24B Growth Version Feasibility Study. AFFDL-TR-73-116, October 1973.
2. Jordan, Gareth H., McLeod, Normal J., and Guy, Lawrence D.: Structural Dynamic Experiences of the X-15 Airplane. NASA TN D-1158, 1962.
3. Rucker, C. E. and Grandle, R. E.: Thermoacoustic Fatigue Testing Facility for Space Shuttle Thermal Protection System Panels. Presented at 1972 Symposium on Fatigue at Elevated Temperatures, Storrs, Conn., June 18-23, 1972, STP520.
4. Rucker, C. E. and Grandle, R. E.: Testing of Space Shuttle Thermal Protection System Panels Under Simulated Reentry Thermoacoustic Conditions. AIAA/NASA/ASTM/IES Seventh Space Simulation Conference, Los Angeles, California, Nov. 12-14, 1973. NASA SP-336.
5. Rucker, C. E. and Mixon, J. S.: Vibroacoustic Testing of Space Shuttle Thermal Protection System Panels. Proceedings of AIAA/ASME/SAE 17th S, SD, and M Conference, King of Prussia, Pennsylvania, May 5-7, 1976.
6. Puster, Richard L. and Chapman, Andrew J.: Experimental Performance of an Ablative Material as an External Insulator for a Hypersonic Research Aircraft. NASA TN D-8490, 1977.

Table 1 - Grazing incidence acoustic fatigue test facility capability.

Facility Parameters		Used in Tests
Sound level	90 to 163 dB rms overall	158 & 160 dB
*Frequency	40 to 500 Hz (sine) & 40 to 1000 Hz (random)	800 & 1600 Hz (random)
Temperature	ambient to 1100C (2012F) in 63 increments	ambient
Specimen size	1.83 by 1.83 m (6.0 x 6.0 ft.)	50.8x50.8 cm (20x20 in.)
Heated area	1.52 m (150 ft.) by 1.8 m (6.0 ft.) high	
Quartz heaters	custom reflector rated at 1 MW	not used

Equipment

Type (temperature limit)	Number Available	Rating	Frequency Limitation	Comments	Used in tests
Strain gages (650 C) (RT)	20 198	gage factor to 4	dynamic only	ADC readout sampled	None
Accelerometers (760 C)	3	2.5 pC/g	1000 Hz	ADC readout	None
Microphones	10	174 dB	40 Hz to 10 kHz	ADC readout	4
Thermocouples (1300 C)	32	chromel-alumel	60 rms readout time	readout from thermometer or storage register	None
Air Modulator	2	30 kW each	40 Hz to 1 kHz	amplitude/frequency	2
Thermal controller	16	50 kW each	80 rms response	digital control	None

*Modulator is rated up to 1000 Hz (random); however, a control input of 1600 Hz (random) was used for the last test.

Table 2 - Summary of Tunnel Conditions

TEST NUMBER	INITIAL 5 MINUTES			FINAL 25 MINUTES		
	dB	(±)N/m^2	((±)PSI)	dB	(+)N/m^2	((±)PSI)
1	159	2027	(.294)	158	1648	(.239)
2	160	2020	(.293)	157	1358	(.197)
3	159	1751	(.254)	158	1634	(.237)
4	161	2186	(.317)	159	1627	(.261)
5	161	2227	(.323)	158	1627	(.236)
6	158	1620	(.235)	156	1276	(.185)

Figure 1.- Insulator/ablator test specimen in 8'HTST.

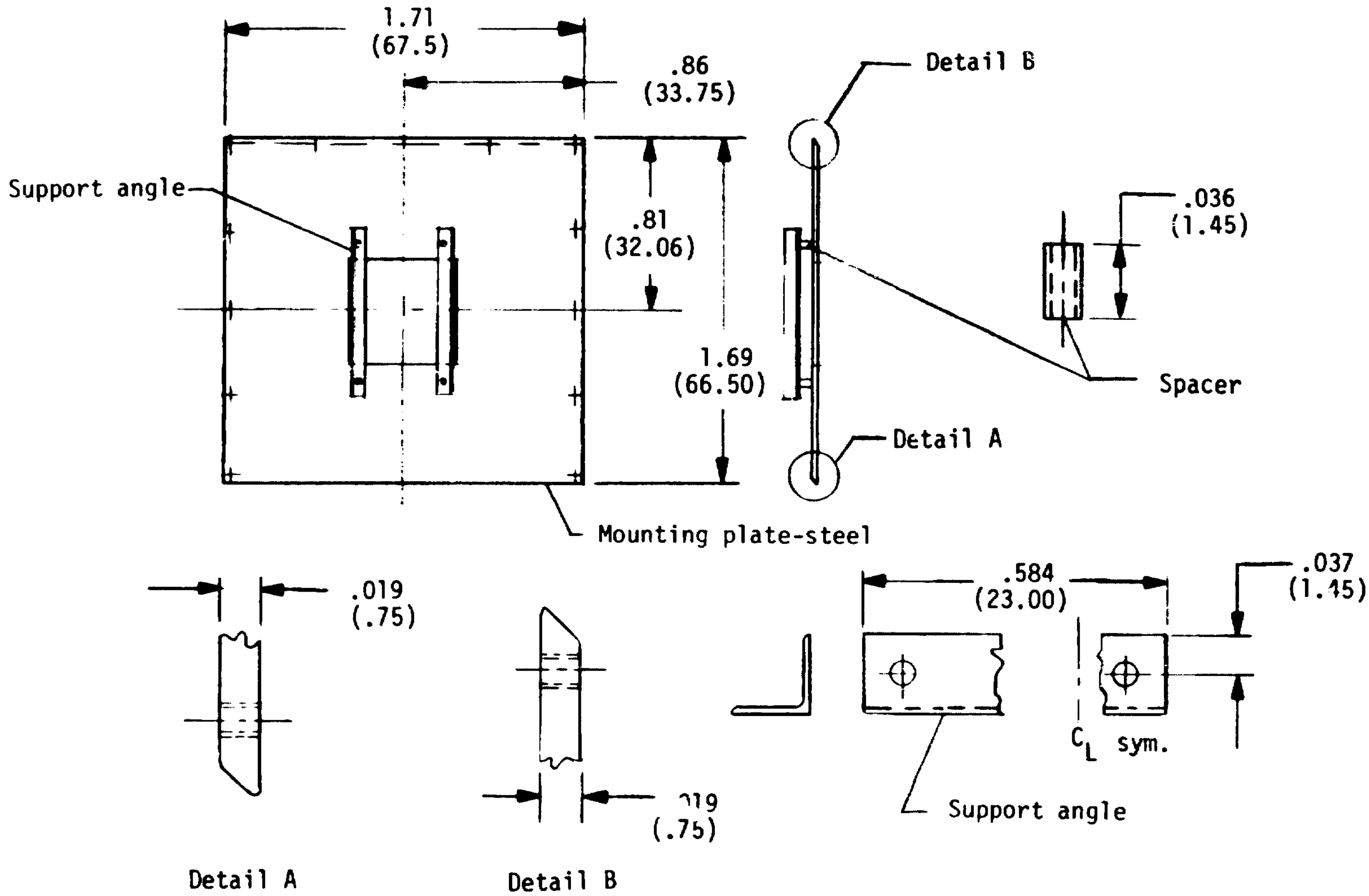

Figure 2.- Mounting plate and support angles.

All dimensions shown in meters (inches)

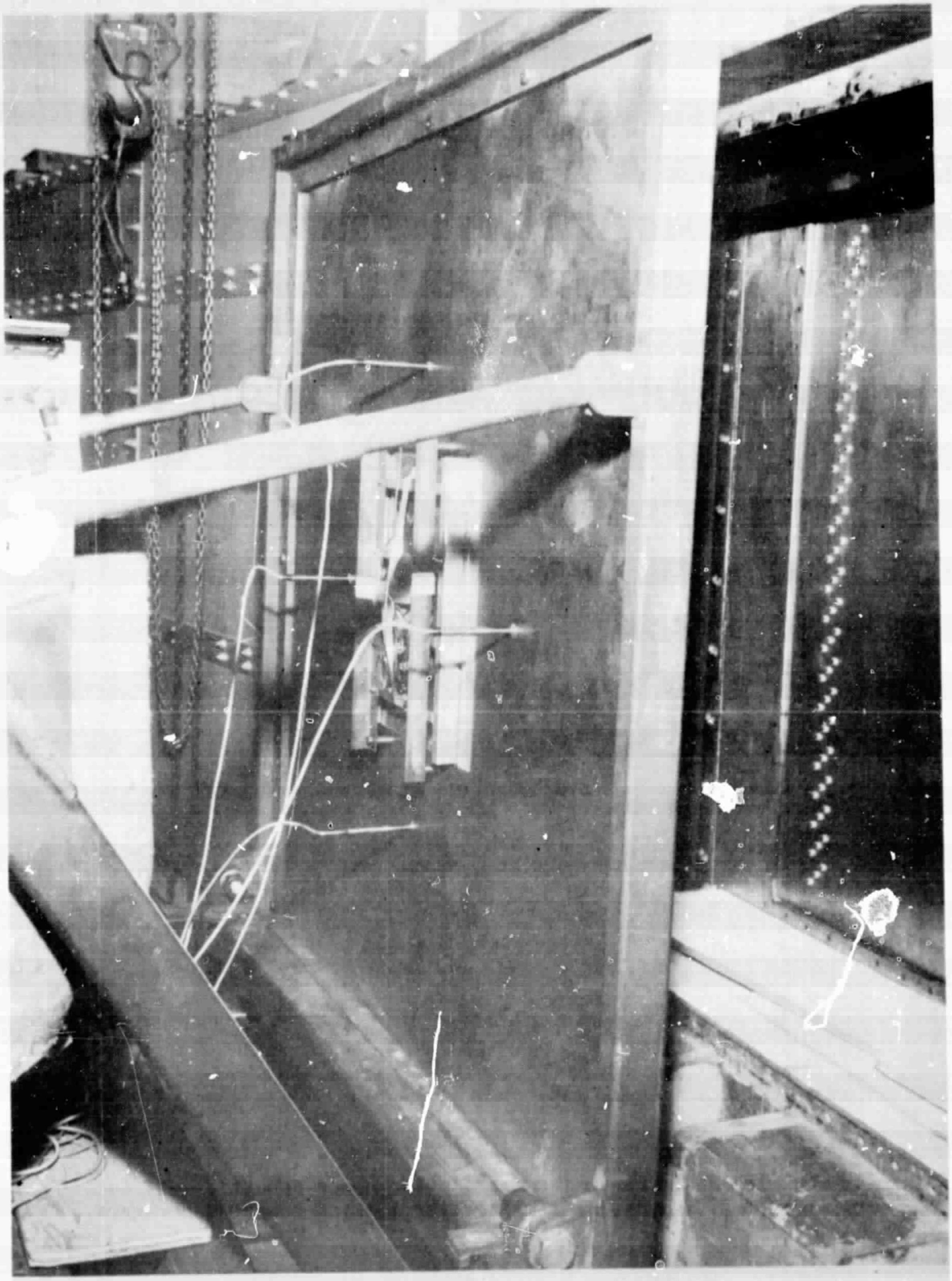

Figure 3.- Test specimen mounted in High Intensity Noise Facility.

ORIGINAL PAGE IS
OF POOR QUALITY

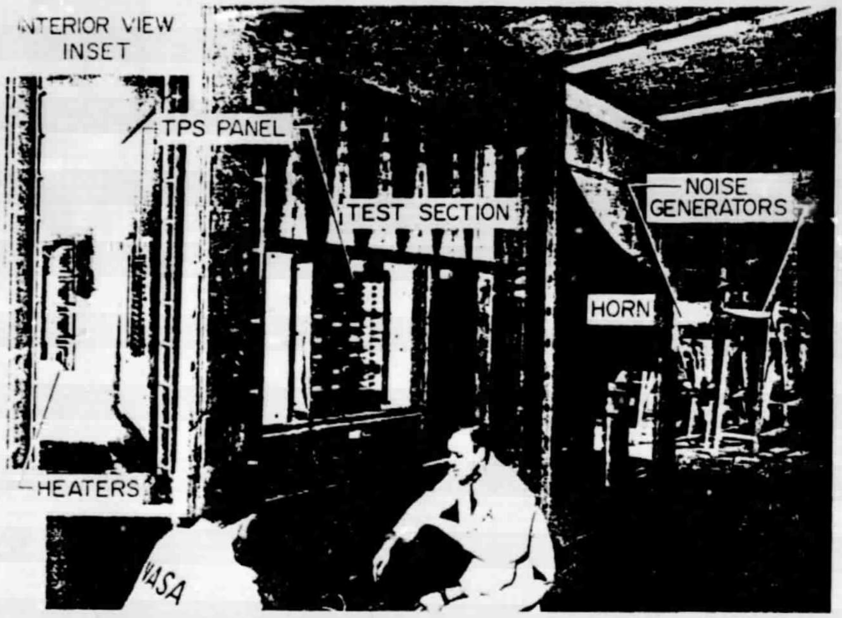

Figure 4.- Langley Research Center grazing incidence acoustic test facility.
(Inset - View inside test section looking toward generators.)

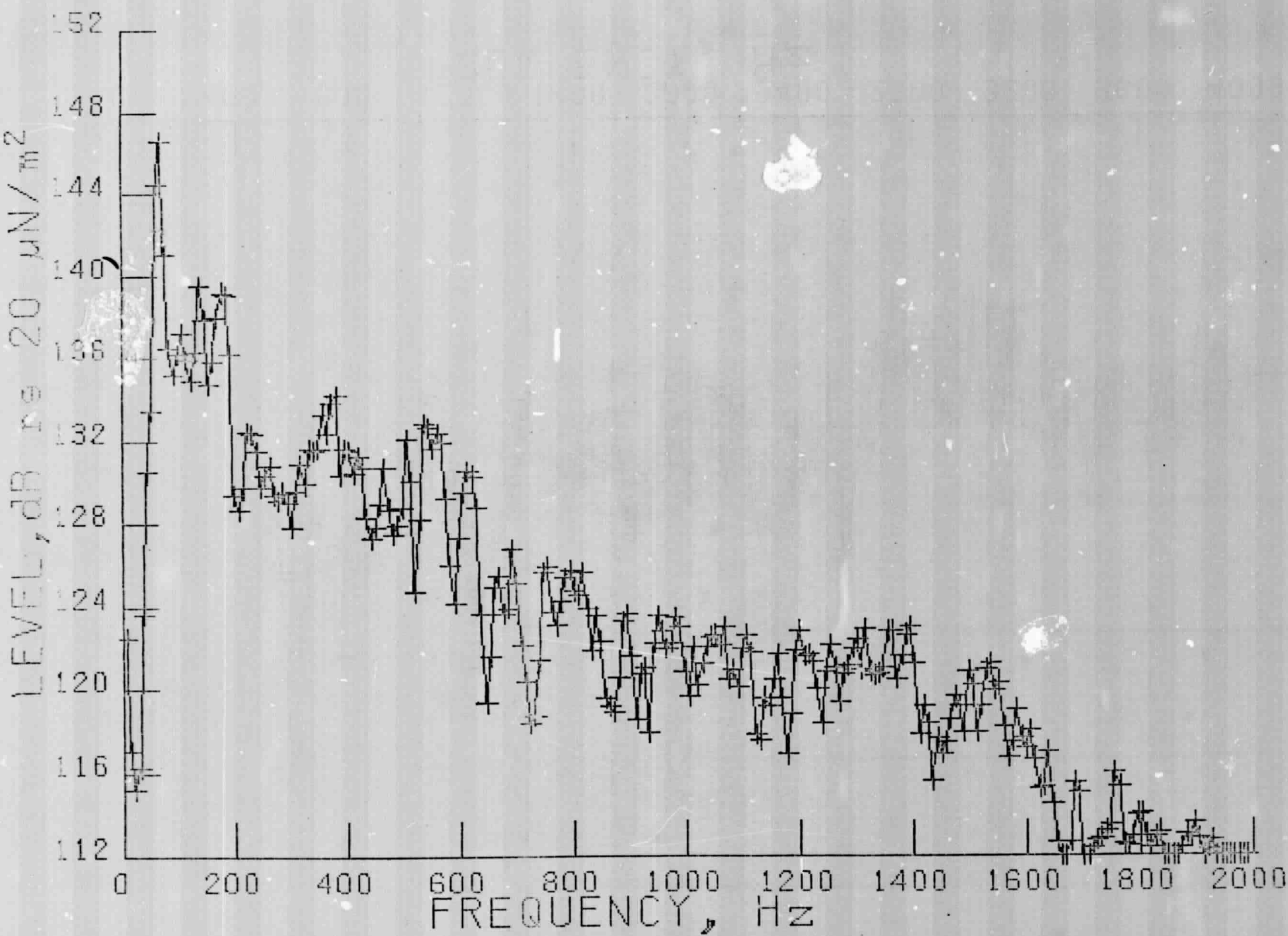

Figure 5.- Noise level as a function of frequency for test number 5.

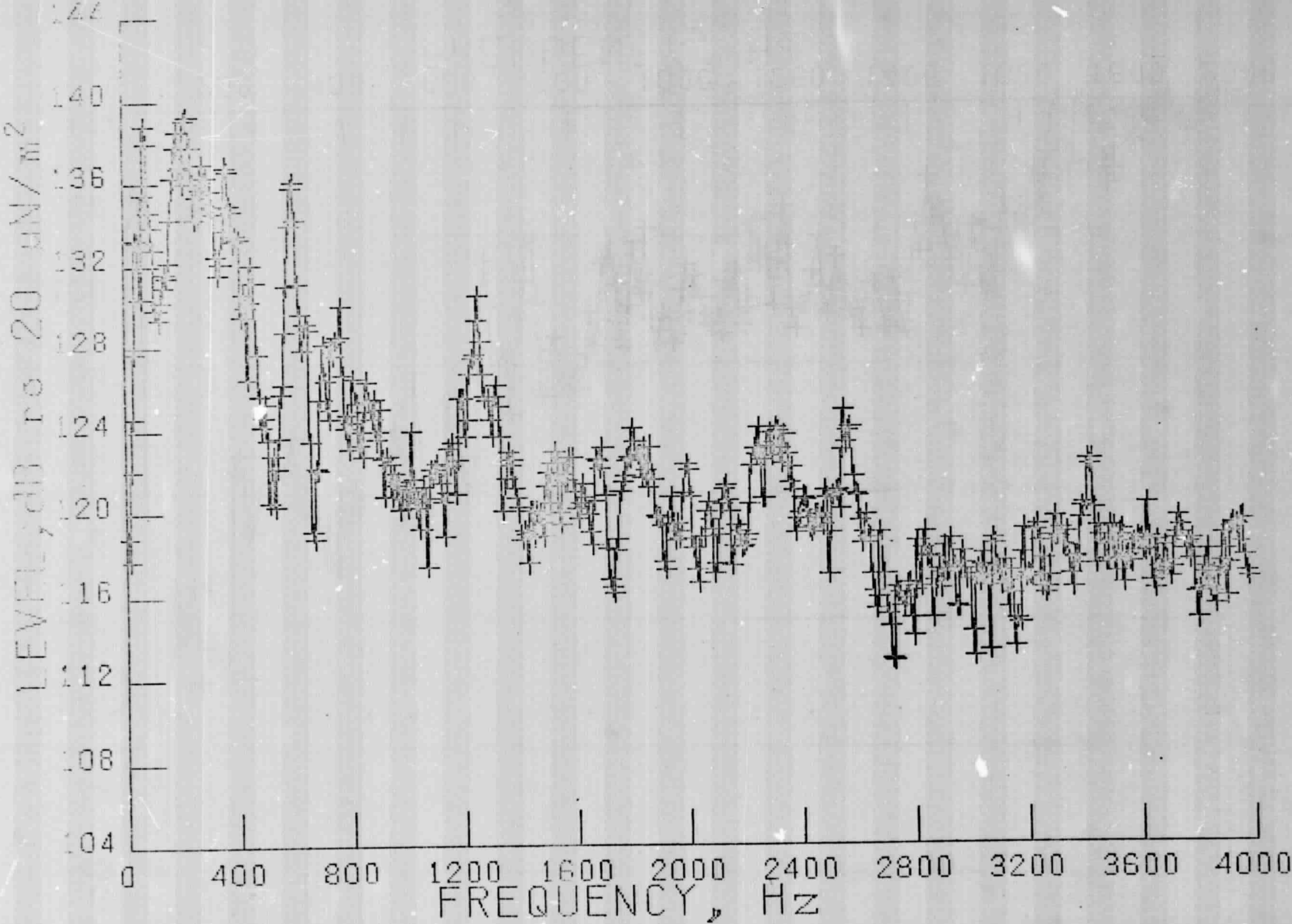

Figure 6.- Noise level as a function of frequency for test number 6.

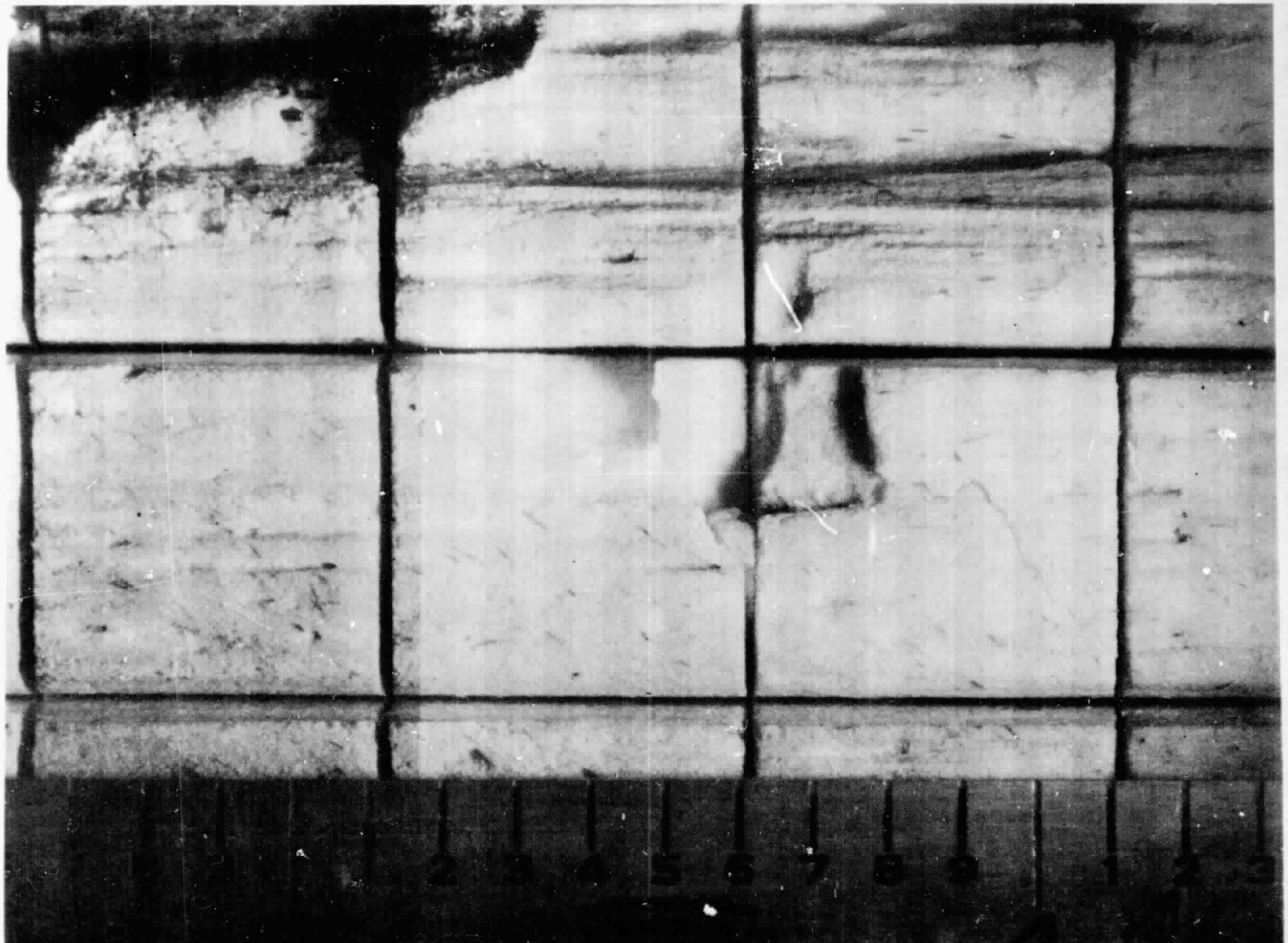

Figure 7.- Striated specimen after sonic tests showing chipped and cracked surface.

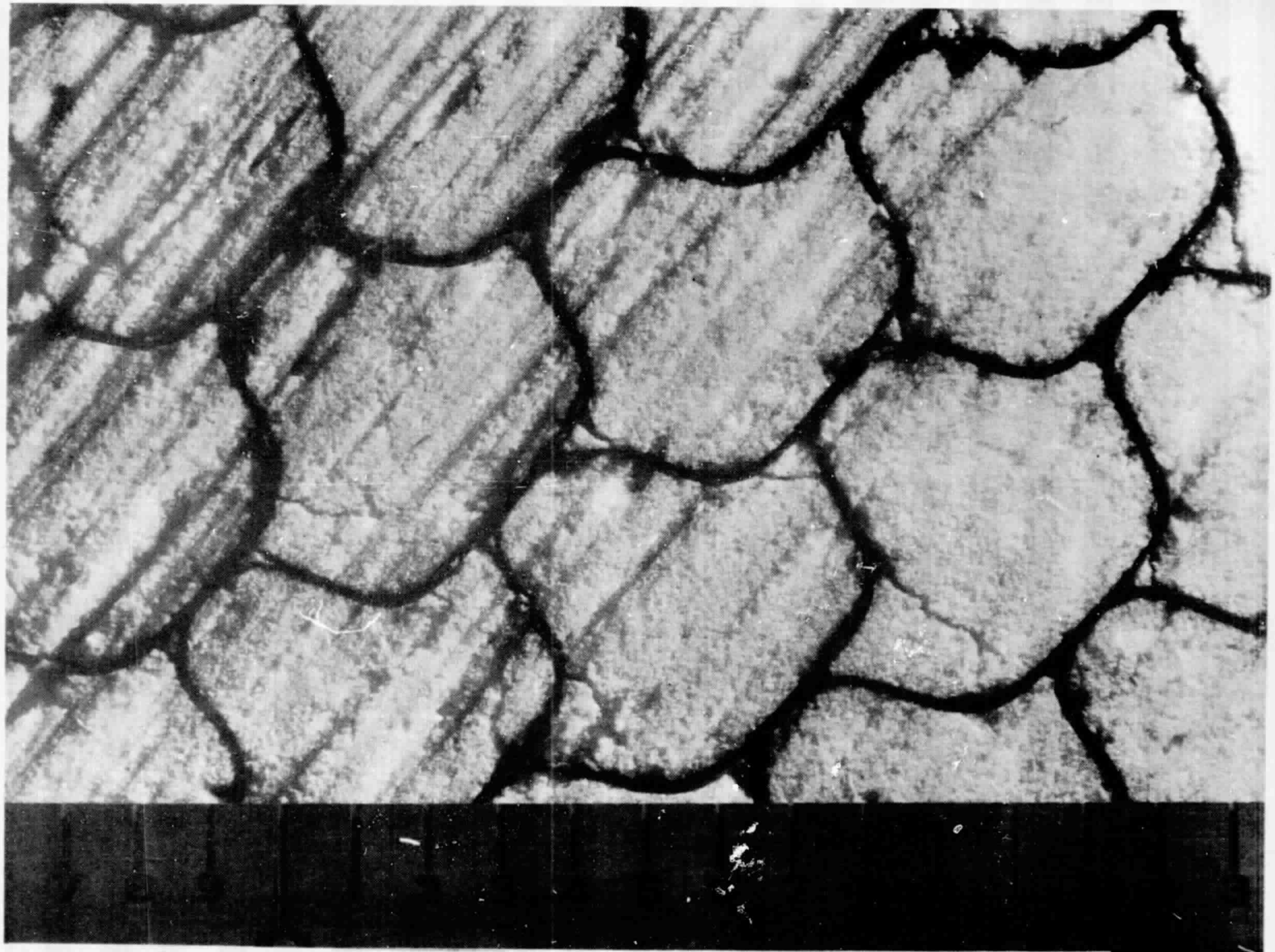

Figure 8.- Honeycomb-reinforced specimen after sonic tests showing cracks.